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SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR MARCH, 1917.

By H. C. FRANKENFIELD, Supervising Forecaster.

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BAL PRESSURE DISTRIBUTION OVER THE NORTHERN HEMISPHERE, EXCEPT EUROPE AND INTERIOR ASIA.

During the first three weeks of the month low pressure, usually of a marked character, prevailed over the western portion of the North Pacific Ocean, depressions having been exceptionally pronounced between the 8th and 10th, and between the 16th and 18th. Over the eastern portion of the North Pacific Ocean, as indicated by the reports from the Aleutian Islands and Alaska, pressures were generally low during the first week of the month, with the greatest fall on the 3d and 4th. From about the 9th to the 19th, inclusive, high pressures prevailed over this area, followed by generally low pressure, except over the Aleutians, where there were several alternations of high and low pressure, each of about two days' duration. The Alaskan depression of the 23d was especially marked, Valdez reporting a barometer reading of 28.62 inches, and Juneau one of 28.68 inches.

The distribution over Alaska was reflected in a lesser degree to the southward and southeastward over the Pacific States and the Northwest, including Canada, and thence eastward to the Atlantic coast.

Over the Middle and South Atlantic Ocean, as indicated by the reports from Bermuda and Turks Island, the pressure was generally high, although not to any pronounced degree, and there were only a few days with pressure below the average. Over the United States proper the LOWS of the month were almost exclusively of the Alberta and Colorado types, and with but two exceptions all passed over the Lakes Region and the districts to the eastward. A single disturbance of the Colorado type moved almost due eastward, passing off the Virginia coast without any unusual development; while another that developed near the mouth of the Rio Grande moved directly northeastward with steadily increasing intensity, finally disappearing in the Atlantic Ocean to the east of Nova Scotia.

STORM WARNINGS.

The evening map of March 3 found the Rio Grande disturbance above mentioned near the mouth of the Mississippi River with a northeastward movement, and as pressure was increasing rapidly to the northwest and northward, northwest storm warnings on the Gulf coast from Pass Christian to Carrabelle were ordered at 10 p. m. By the morning of March 4 the disturbance had moved to northern Georgia, and southwest warnings from Jacksonville, Fla., to Hatteras, N. C., were ordered at 11:30 a. m., with instructions to change to northwest at sunset. At the same time northeast warnings were ordered on the Atlantic coast from Washington, N. C., to New York City. On the evening of March 4 the storm was central over extreme western North Carolina, with quite high pressures to northeastward, and northeast warnings were therefore ordered on the middle Gulf and south Atlantic coasts as far south as Jacksonville. On the

morning of the 5th the storm was central over New Jersey, with a further increase in intensity, and moderate northeast gales were in progress on the New England coast. During the day west and northwest gales also occurred along the middle Atlantic coast. At 11:30 a. m. the northeast warnings displayed from Washington, N. C., to New York were changed to northwest, and at 10 p. m., when the storm was central off the southern New England coast, the warnings on the New England coast were changed from northeast to northwest, and gales continued until after the morning observation of March 6, with velocities ranging from 40 to 60 miles an hour.

While this storm was passing over the eastern portion of the country, another disturbance from the northern Pacific coast had moved southeastward and eastward and was central over eastern Nebraska. Accordingly, advisory warnings for strong southeast and south winds were sent to open ports on Lake Michigan; on the following day strong winds occurred as forecast.

By the evening of the 7th this second storm was central over northeastern Wisconsin, with marked high pressure to the southeastward, and at 10 p. m. southwest warnings were ordered on the Atlantic coast from Delaware Breakwater to Eastport, Me. However, this storm did not maintain its original intensity; a moderate secondary disturbance developed over Virginia during the night of the 7th, and the storm warning failed of verification, only fresh winds having occurred.

By the night of March 10 another western disturbance was central over Iowa, with a high pressure area of considerable magnitude over the Atlantic States, and at 10 p. m. southwest storm warnings were ordered on the Atlantic coast from Hatteras to Portland, Me. This disturbance also failed to maintain its intensity after leaving Iowa, so that while moderately strong winds occurred locally along the Atlantic coast, there were none of consequence. By the night of the 10th, owing to the presence of a disturbance central over southeastern New Mexico, southeast storm warnings were ordered on the Gulf coast from Pass Christian to Carrabelle, but as this disturbance failed to develop further, no strong winds occurred. On the night of the 12th marked high pressure prevailed over Lake Superior, with an increasing disturbance over western Texas. Accordingly, advisory warnings of strong northeast winds with snow were sent to open ports on Lake Michigan. This warning was fully justified, both as to wind and weather. On the morning of the 14th the last-mentioned storm was central over upper Michigan, with greatly increased intensity, and southeast storm warnings—to be changed to southwest at sunset—were ordered at noon along the Atlantic coast from Norfolk, Va., to Eastport, Me. Moderately strong winds followed along the New England coast, but there were none of consequence to the southward, and at 10 a. m. of the 15th the warnings were lowered.

The Colorado disturbances continued their rapid sequence, and on the evening of the 15th another was central in pronounced form over western Kansas, and advisory warnings for strong northeast winds, with snow, were again sent to open ports on Lake Michigan and were again verified by the occurrences of the following day.

By the morning of the 17th this storm was central over extreme eastern Lake Superior, with greatly increased intensity and with an eastward movement, and accordingly southwest storm warnings were ordered at 10:30 a. m. along the Atlantic coast from Norfolk to Eastport. These warnings were fully verified, New York reporting a velocity of 56 miles an hour from the southwest. On the morning of the 18th, with the storm central over the Province of Ontario, the southwest warnings were changed to northwest from Delaware Breakwater to Eastport and the high winds continued throughout the 19th, with a maximum velocity of 72 miles an hour at New York and 52 miles an hour at Portland, Me.

On the morning of the 19th an Alberta disturbance was central over Manitoba, with marked high pressure over the Ohio Valley and south, and at 2 p. m. advisory warnings for strong southerly winds were sent to open ports on Lake Michigan. This disturbance did not develop materially and no winds of consequence occurred. The next western storm reached northwestern Missouri on the night of the 22d, with increasing intensity, and again advisory messages of strong winds with rain or snow were sent to open ports on Lake Michigan, and winds occurred as forecast, accompanied by rain. This storm moved rapidly eastward after reaching the upper Lakes region, and on the morning of the 23d southwest storm warnings were ordered on the Atlantic coast from Norfolk to Eastport. During the next 24 hours strong winds and moderate gales occurred as forecast, and on the morning of the 24th, when the storm was central over the lower St. Lawrence Valley the warnings on the Maine coast were changed to northwest and allowed to expire to the southward. By the night of the 24th the winds had diminished and the warnings on the Maine coast were lowered. The next western storm reached Georgian Bay by the morning of the 27th, and at 10:30 a. m. storm warnings were ordered on the Atlantic coast from Wilmington, N. C., to Eastport, Me., with instructions to change to northwest at sunset. These warnings were fully verified by subsequent occurrences, Portland, Me., reporting a maximum velocity of 68 miles an hour from the southeast during the night of March 27-28.

By the night of the 28th an Alberta disturbance was central some distance south of James Bay, with a rapid eastward movement, and southwest storm warnings were again ordered from Delaware Breakwater to Eastport. This disturbance continued to increase in intensity as it moved eastward, and gales occurred as forecast. On the night of the 30th the last disturbance of the month was central over eastern Nebraska. This disturbance was apparently of a decided character, and advisory warnings were sent to open ports on Lake Michigan for increasing south winds, to become strong and shifting to colder northwest. Moderately strong winds occurred, but none of much consequence.

Small-craft warnings were ordered at various times during the month along the middle Gulf and south Atlantic coasts for moderately strong winds that occurred.

COLD WAVES AND FROSTS.

On the evening of March 2 an extensive high pressure area, accompanied by quite low temperature, was central over the extreme Northwest and warnings of a moderate cold wave were accordingly issued for upper Michigan. By the evening of the 3d there was a marked fall over this section and on the morning of the 4th there was a decided cold wave with temperatures ranging from 4° to 14° below zero, and there was also a moderate cold wave

over northern and western lower Michigan. At this time the Rio Grande disturbance previously mentioned was central near the mouth of the Mississippi River with the cold high area to the north of still further increased magnitude and intensity. On the following morning warnings were issued for cold waves to occur during the next 36 hours over the Carolinas, Georgia, Alabama, Mississippi, northwest Florida, Tennessee, and portions of Ohio and Indiana. These warnings were fully verified on the morning of the 5th, except over western Tennessee, Indiana, and Ohio, where the fall in temperature was not sufficient to justify a cold-wave warning. On the morning of the 5th warnings of temperature below freezing were issued for the Carolinas, Alabama, northern Florida, and interior Mississippi; also heavy frost warnings for central Florida, and light frosts in southern Florida as far south as the 27th parallel, and on the morning of the 6th heavy frosts occurred as far south as Eustis, Fla., and light frosts as far south as Tampa.

On the morning of the 8th with a cold high pressure area over the west Gulf States, warnings of light frosts were issued for the northern and central portions of Alabama and Mississippi, and frosts occurred as forecast on the following morning, extending into the interior of Georgia. Frost warnings were then repeated for the interior of South Carolina and for the central and northeastern portions of Georgia, and heavy frosts occurred on the morning of the 10th over the Atlantic district.

On the morning of the 14th, with a moderate secondary depression over eastern Tennessee and a moderate high pressure area over Arkansas, warnings of light frost were issued for Mississippi, interior Alabama, and central and northwest Georgia, and these warnings were generally verified by the occurrences on the following morning, except in Mississippi, where the weather became cloudy. On the morning of the 15th light frosts were forecast for the following morning for the interior of the Carolinas, but the rapid approach of one of the western disturbances brought on cloudy weather and a consequent rise in temperature. On the morning of the 17th, by which time the western disturbance had passed northeast of Lake Superior, and a cold high area had reached northern Texas, frost warnings were again issued for the East Gulf States, Georgia, the Carolinas, and eastern Tennessee. On the morning of the 19th heavy and killing frosts occurred over the entire district for which the frost warnings had been issued and warnings were again issued for heavy frosts in the Carolinas and central and northeastern Georgia, and for freezing temperature in Virginia. These warnings failed on account of a rapid change to cloudy weather due to another western disturbance.

On the morning of March 24 pressure was moderately high over the West Gulf States and low to the eastward and warnings for light frosts were issued quite generally for Tennessee, and the East Gulf and South Atlantic States, except Florida, and on the morning of the 20th frosts were reported from the East Gulf States, Tennessee, and southern Virginia, but none in the Carolinas and Georgia. On the morning of the 27th the same general conditions prevailed as on the 24th but with a more decided high area over Texas, and warnings of light frost were again issued for the East Gulf and South Atlantic States, and of heavy frost for Tennessee. These warnings were fully verified by the occurrences on the morning of the 28th, at which time frost warnings were repeated for Virginia, the Carolinas, eastern Tennessee, and interior Georgia. These warnings were partially verified as to Georgia and the Carolinas.

WARNINGS FROM OTHER DISTRICTS.

Chicago district.—As the month of March is between the cold wave and frost warning seasons, special warnings during that month are seldom issued in the Chicago district, and March, 1917, was no exception to this rule. However, a few warnings were issued on the 2d and 3d for Illinois, Missouri, Wisconsin, Minnesota, and Iowa, in advance of a cold wave which pushed down from Alberta. This was the most general warning of the entire month, and thereafter no severe temperatures were observed in the district, except over a small area in the Northwest on the 18th. In the third decade of the month the temperatures were above the normal as a rule, and they reached such a high point in Kansas by the 25th that frost warnings were deemed necessary, and advices were issued to that State on the 26th for a severe freeze. The fall there was quite marked, the temperature falling far below the freezing point.

No warnings of any other character were issued during the month.—*H. J. Cox, District Forecaster.*

New Orleans district.—On the 4th an area of high pressure was moving southeastward over the upper Mississippi Valley and the Plains States and a steep barometric gradient extended to an area of moderately low barometer over the East Gulf States. Northwest storm warnings for the Texas coast and small craft warnings for the Louisiana coast were issued and were verified.

Southeast storm warnings were ordered for the Texas coast at 2:40 p. m. on the 10th, as a midday special observation from Corpus Christi, Tex., indicated that a depression over the southern Rocky Mountain slope was apparently increasing in intensity. The wind did not reach verifying velocity on the east coast, but at Corpus Christi a velocity of 48 miles was recorded. With the low area central over eastern New Mexico on the p. m. map of the 11th, and threatening conditions obtaining along the west coast of Texas, southeast storm warnings were again issued for the Texas coast. Slightly less than the verifying velocity was recorded at Corpus Christi during the ensuing 24 hours, but there were no gales on the east coast.

On the evening of the 26th an area of high pressure was central over the middle Rocky Mountain region and a steep barometric gradient extended into Texas. Northwest storm warnings were ordered for the Galveston section and were verified.

Small-craft warnings were issued for the Texas coast on the 1st, 6th, and 23d, and strong winds occurred as forecast, except on the 1st, in which case the weakening of an area of high pressure, which moved eastward over the Plains States, prevented the wind from increasing on the Texas coast.

The area of high pressure that was over the northern portion of the country on the 1st advanced slowly southeastward, with intensity increasing until after the 4th, and passed to the East Gulf States by the afternoon of the 5th. On account of the gradual lowering of the temperature no cold-wave warnings were issued and no cold waves occurred except in southeastern Louisiana, where the temperature remained high until the 4th. Warning of freezing in the interior of eastern Texas was issued on the 1st, but the movement of the cold area was slower than expected and freezing temperatures occurred only in part of the northwestern portion of east Texas. The retarding effect was due mainly to the continued presence and slight development of a depression over New Mexico. On the 3d the low-pressure area over New Mexico was filling up,

and a warning of freezing in northern Louisiana and the interior of eastern Texas, issued on this date, was fully verified.

On the 4th warnings of a hard freeze in the interior of Louisiana and Texas and freezing to the coast were issued and were verified.

Frost warnings for Louisiana were issued on the 5th; for Arkansas, northern Louisiana, and the interior of Texas, on the 7th; for Arkansas and the interior of Louisiana and east Texas, on the 8th; for the western and north-central portions of east Texas, on the 13th; for Arkansas, northern Louisiana, and the extreme northern portion of eastern Texas, on the 14th; for Arkansas and the interior of Louisiana and Texas, with freezing in northwestern Arkansas and below freezing in Oklahoma and the northern portion of western Texas, on the 17th; for Arkansas and the interior of Louisiana, on the 18th; for Arkansas, northwestern Louisiana, and the interior of Texas, with freezing in Oklahoma and the northern portion of west Texas, on the 23d; for northwestern Arkansas and the interior of east Texas, with freezing in western Oklahoma and the northern portion of west Texas, on the 26th; for the interior of Louisiana and east Texas, on the 27th. Freezing temperature was forecast for Oklahoma, northwestern Arkansas, and the northern portion of west Texas, on the 16th. The foregoing warnings of frost and freezing temperature were verified except the frost warning of the 14th, which failed, because of rising temperature due to the development of a depression that moved from Utah to northern New Mexico, and the frost warning of the 18th, which was mostly unverified because of cloudiness in Arkansas and western Louisiana, not foreseen when the forecast was made. In the latter instance temperatures were around 40°. The frost forecast of the 8th was partially verified. Temperatures in western Oklahoma and the Texas Panhandle were generally slightly above freezing on April 1, following the warning of freezing temperature issued on March 31.

Fire-weather warnings for the forested areas of Arkansas were issued on the 6th, 10th, and 15th, and for Arkansas and Oklahoma on the 19th and 30th. Wind velocities and weather generally occurred as forecast in these warnings.—*R. A. Dyke, Assistant Forecaster.*

Denver district.—The weather conditions during March in the Denver district were more unsettled than usual. Active low-pressure areas were central somewhere in the district during two-thirds of the month. In the main the tracks of these disturbances were farther south than usual, and under the influence of the higher pressures that followed there was a persistence of unusually cold weather in the extreme southern part of the district. Frosts were common in central Arizona and freezing temperatures in southeastern Arizona and southern New Mexico. On the morning of the 10th a low-pressure area was central in southeastern Colorado with loops of the depression extending southwestward to northern Arizona. A cold-wave warning was issued for northeastern Arizona. The primary low moved eastward, leaving a portion west of the Rocky Mountains which later developed into an important disturbance. The expected cold in northeastern Arizona did not occur until 12 hours after the period covered by the warning. Under the influence of a depression on the eastern Rocky Mountain slope very high temperatures prevailed on the morning of the 30th in northern Colorado and Wyoming. Warnings of a moderate cold wave were issued for northern Colorado in the forenoon and much colder for

Colorado in the afternoon. The warnings were verified by temperature falls of 22 to 44 degrees in northern and eastern Colorado. On the morning of the 31st a low-pressure area was central in northwestern New Mexico with high pressure on the middle Pacific coast. Warnings of a cold wave in central and northeastern Arizona were issued. Sharp temperature falls occurred but they lacked 2 degrees of the required amounts, and in central Arizona the required minimum was not reached by 2 degrees. The warnings of frost in central Arizona, of which there were 17, were fully verified as a rule.—*Fred. H. Brandenburg, District Forecaster.*

San Francisco district.—The storms moved eastward well to the north and gave precipitation only in the northern portion of the district, except that of the 8th, which moved rapidly southeastward along the eastern slope of the Sierra Nevada and gave rain to the entire district. Rain was forecast only for the north section.

Frosts occurred frequently in all sections, but owing to the backwardness of the season, the damage was slight in most places.

Storm warnings were issued on the 8th, along the north coast and on the 10th, along the south coast, and in both instances were justified.—*G. H. Willson, District Forecaster.*

Portland, Oreg., district.—In this district March, 1917, was rather more stormy than usual, and in general there was a slight excess in the amount of precipitation in western Oregon, also in western Washington except at Seattle where there was a deficiency. East of the Cascade Mountains less than the normal amount of precipitation occurred, due to the controlling influence of the high pressure areas, most of which moved eastward or northeastward from the Oregon-California coast. Our weather conditions were dominated by high pressure areas during the first three days of the month, on the 5th and 6th, from the 14th to the 18th, inclusive, and again on the 25th. On the 4th, from the 7th to the 13th, the 19th to the 24th, and the 26th to the 31st, low pressure areas were the dominating factors; those during the second and fourth periods mentioned were forced farther south than usual by areas of high pressure over northwestern and central Canada.

Storm warnings were issued on 12 dates; 10 were general warnings and 2 local, and all were verified except those on the 8th and 12th, while one on the 26th was partially verified. Of these warnings, 9 were southwest, 1 northwest and 2 southeast. Subsequent developments proved that storm instead of small-craft warnings ought to have been hoisted at the mouth of the Columbia River on the morning of the 28th; all the other warnings were timely and, excepting the northwest warning on the 8th, necessary.

Small-craft warnings were ordered on 8 days and all were justified.

As has been customary, frost warnings were resumed this month for western Oregon and western Washington. Of the 11 frosts predicted 8 were verified, and 3 were not on account of cloudiness. These warnings were all general for the section mentioned. On account of the lateness of the fruit blossoming season in the Rogue River Valley, definite forecasts of expected minimum temperatures were not asked for until the morning of the 27th. On the 30th a warning of heavy frost sent out in the morning was supplemented by an evening prediction of a

minimum temperature of 27°; the actual minimum recorded was 25°, but so far as known little, if any, damage resulted as buds were not very far advanced.

A cautionary warning of prevailing weather conditions favorable for the occurrence of avalanches in mountainous sections was sent out on the 26th. The snow depth in the mountains is greater than usual according to reliable reports.

Warnings in the interest of the stockmen were sent out generally on five dates. Of these three were for expected unfavorable weather conditions and two were for periods of favorable weather, and all were justified and timely. On account of the unusual depth of the snow in the mountains and on the customary feeding grounds, more than the normal amount of dry feeding has been resorted to; this has resulted in a serious shortage of hay in some localities, and stockmen are very anxious to get any definite information regarding favorable weather if it is expected to continue for several days in order that they may, when practicable, move the stock to available grazing grounds. The feed shortage has resulted in a weakened condition of sheep especially, so that many ewes will probably not survive the lambing season, and the lambs will probably be so weak that many of them will die. Such reports as we have received indicate that these warnings are appreciated by the live stock interests. On March 8, Dan P. Smythe, of Smythe Bros., prominent sheepmen of Arlington stated:

The special forecast furnished by the Weather Bureau is proving of great value to stockmen, particularly to the sheepmen. The service has only been furnished for a year and during that time I have had occasion to observe that the predictions of big storms have been made with wonderful accuracy.

Personally I know that Smythe Bros. have on a number of occasions benefited from them, and we are learning to watch them with serious concern. When a sudden change in the weather is predicted, we always take precautions to protect our stock. The last big storm which broke over eastern Oregon was predicted in time to give the sheepmen time to prepare for it. Those who did, did not suffer.

I have talked with many sheepmen who at first ridiculed the service and find that all have been converted to its value. They are ready to testify to the direct benefits they have derived. I believe that when the system of warning stockmen is developed it will prove as big a boon as are the forecasts to the shipping interests.

On March 14th, Forest Supervisor Homer Ross of Prineville, Oreg., wrote us as follows:

Your telegram to this office on the morning of March 12 was of great value to the stockmen and the public in general in this community. When your telegram arrived about 9 a. m. the sky was clear, the sun shone warm, and it appeared as though our long stormy spell was over. In spite of this, your forecast predicted cold, windy weather with snow that night. This information was telephoned from this office out along the various telephone lines leading into the communities where cattlemen and sheepmen reside, and in addition was posted in the post-office window. That afternoon it turned extremely cold with high wind and snowed considerably during the night.

On March 24th, the vice president of the First National Bank of Jerome, Idaho, wrote us:

The weather forecasts received from your office are very much appreciated by stockmen in this locality. On account of the extraordinary winter weather these forecasts will probably be very helpful for another few weeks. The reports have checked out quite closely with the actual conditions here. On account of being better supplied with feed than most sections, no live stock losses have as yet been experienced even though the weather has been quite severe at times. If the weather should continue severe for another couple of weeks there is a possibility of some losses. It is raining, however, to-day, which you will note is in accordance with your forecast and the stockmen are feeling more hopeful.

—*T. Francis Drake, Local Forecaster.*